

The background of the slide is a deep space photograph, likely from the Hubble Space Telescope. It shows a dense field of galaxies and stars. The galaxies are of various shapes and sizes, some appearing as bright, irregular blobs, while others are more distant and faint. The stars are scattered throughout the field, with some showing prominent diffraction spikes. The overall color palette is dominated by black, with highlights of blue, white, and orange-red from the celestial objects.

Hayley Austin and Collin Van Son Present




The background of the slide is a deep space photograph, likely from the Hubble Space Telescope. It shows a dense field of galaxies, many of which are small, distant, and appear as faint, colorful specks. Some galaxies are more prominent, showing distinct spiral or elliptical shapes. The overall color palette is dominated by blacks and greys, with scattered points of light in various colors including white, blue, red, and orange. The text "In association with Neel Savani" is centered in a yellow, sans-serif font.

In association with Neel Savani



Exploring the Real-Time Value of the Bz4Cast Tool

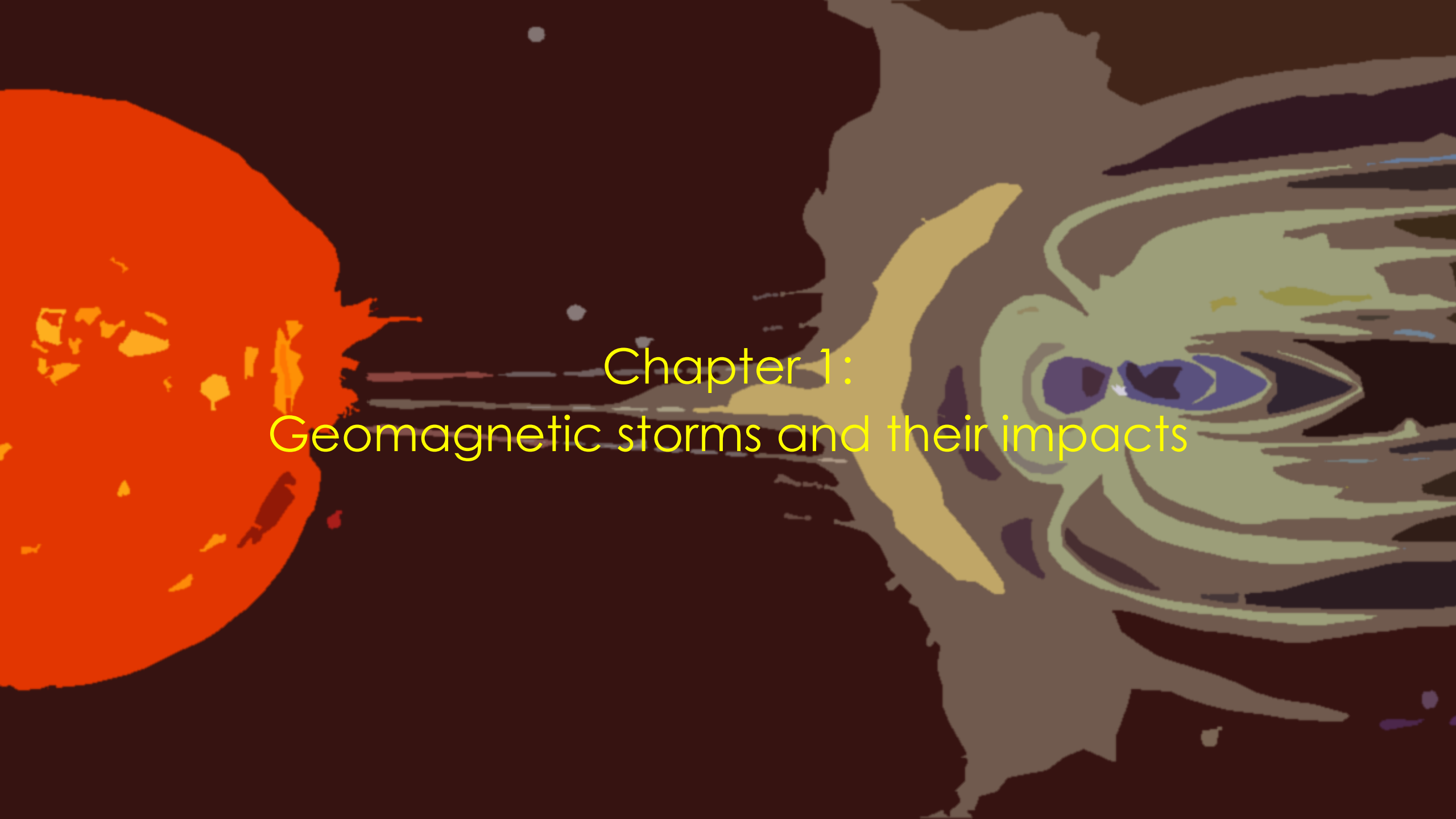


The background of the slide is a deep space photograph, likely from the Hubble Space Telescope, showing a dense field of galaxies and stars. The galaxies are small, distant objects, appearing as faint, irregular shapes in various colors (blue, red, white). The stars are larger, brighter objects, appearing as distinct points of light with some showing diffraction spikes. The overall scene is a vast, dark expanse of the universe.

Prologue: Project Overview

Overview

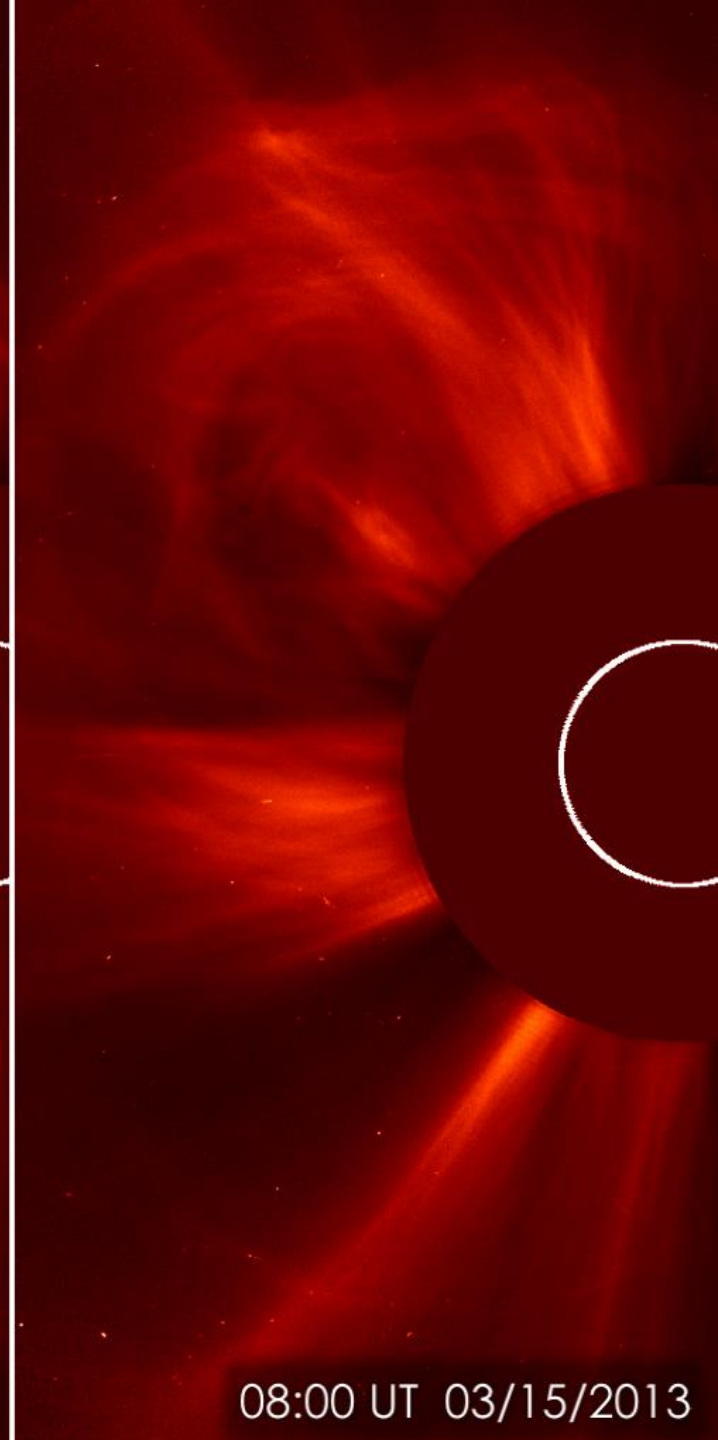
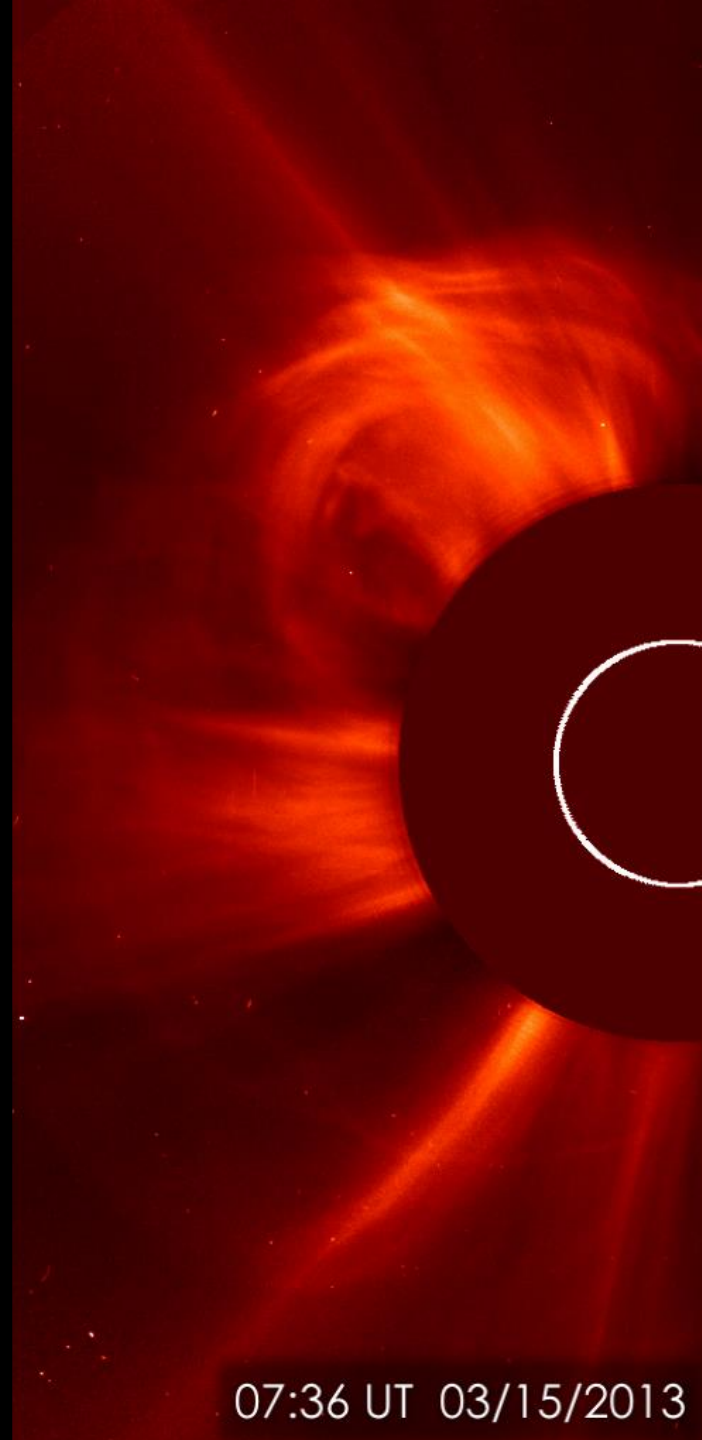
- The Bz4Cast Tool predicts the orientation of a CME's magnetic field
- To improve the quality of model inputs, the accuracy of ENLIL's magnetic field and solar wind speed predictions were measured using a sample of 53 CMEs
- “Rules of thumb” were developed to modify ENLIL predictions into more valuable inputs
- Evaluated using an array of skill scores

The background of the slide is a composite image. On the left, a large, bright orange and yellow sun is shown with visible solar flares. A beam of light or solar wind extends from the sun towards the right. On the right, a stylized representation of Earth's magnetic field is shown, with blue and white concentric loops. A satellite is depicted in orbit around Earth, with a long, thin antenna or solar panel extending outwards. The overall scene is set against a dark, starry space background.

Chapter 1: Geomagnetic storms and their impacts

Geomagnetic Storms

- Caused by Coronal Mass Ejections (CMEs) that carry intense magnetic fields
- Depending on field orientation, can cause severe disruption of Earth's magnetic field



Impacts

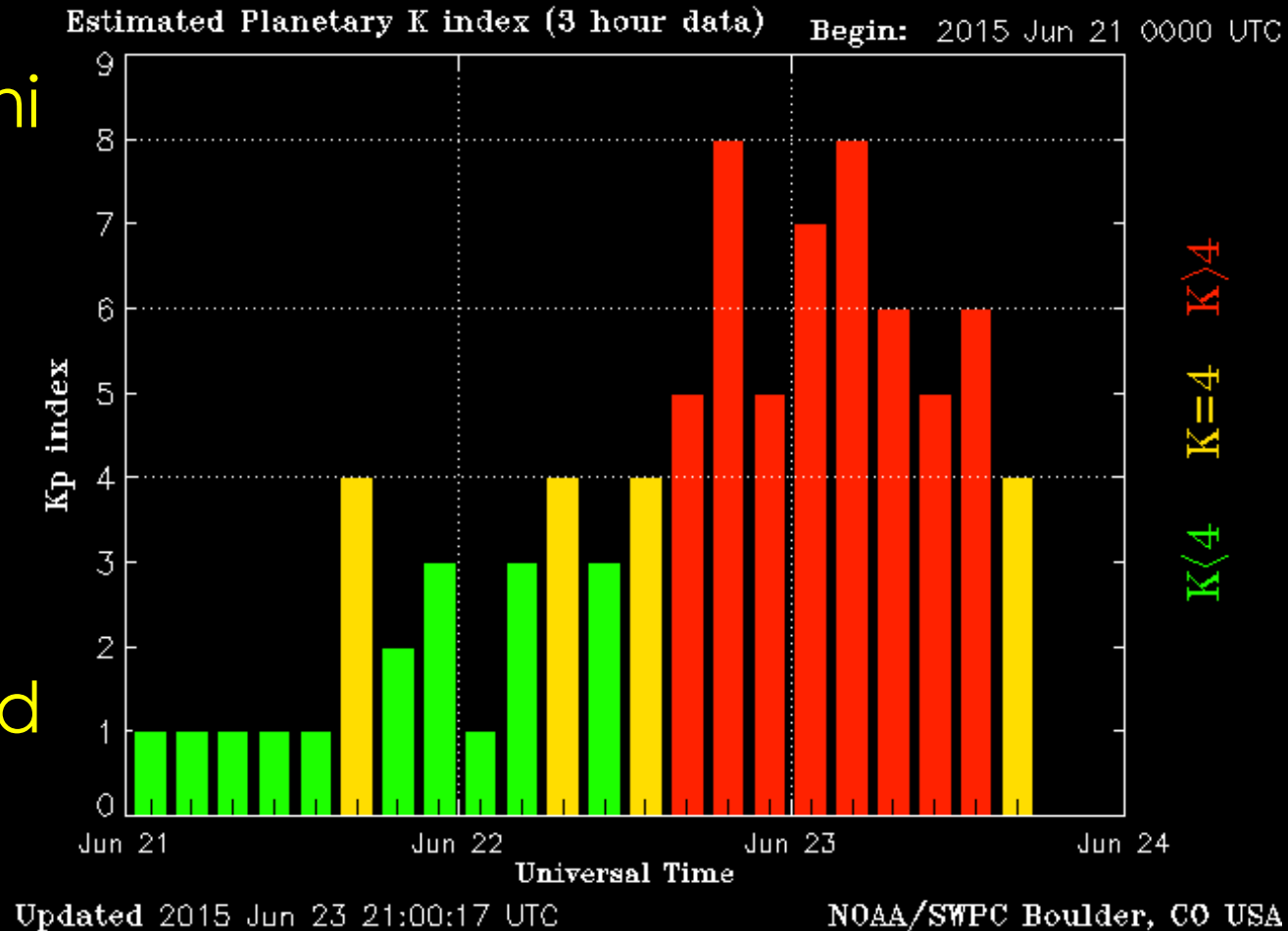
- Interfere with satellite operations
 - Surface charging
 - Single event upsets
- Interrupt power grid operations
 - Ground induced currents
- Disrupt GPS signals and communications
- Enhanced auroras



Chapter 2: The Bz4Cast Tool: Advantages and Limitations

The Bz4Cast Tool

- Developed by Dr. Neel P. Savani
- A statistical and topological model that predicts geomagnetic storm intensity
- Current Kp predictions are based off observations at L1, leaving less than an hour of lead time
- Bz4Cast allows Kp predictions to be made days in advance



Inputs Part I

BzTool

INPUT: Cone or GCS model

Solar Storm Origin

Lat:

Lon:

Axis Tilt angle

Half Angular Width

INPUT: Solar Surface

Leading polarity of Source Region

INPUT: SWRC Enlil Forecast Values

Leading Edge Arrival Time

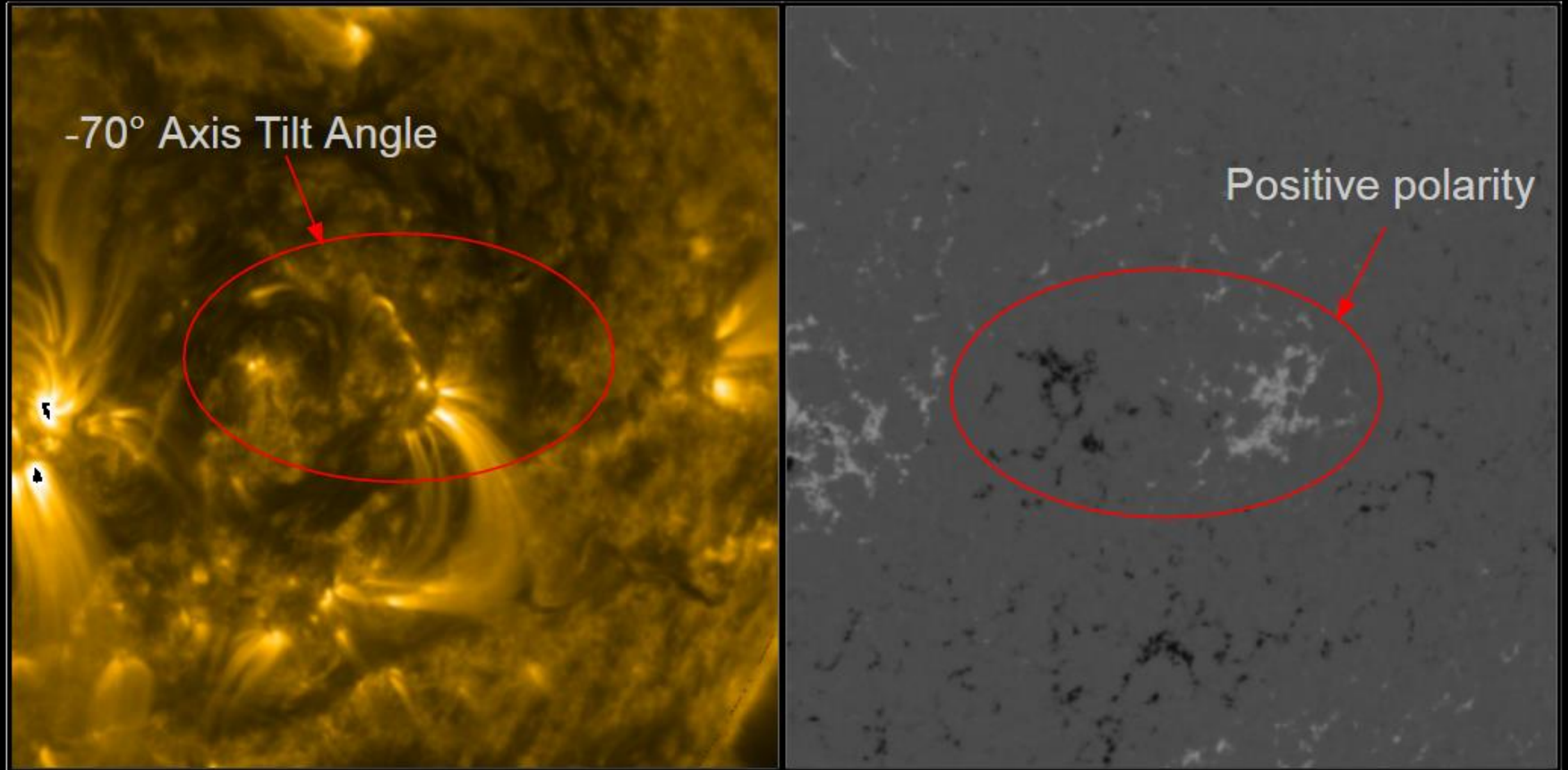
IBI max prediction at L1 [nT]

IVI max prediction at L1 [km/s]

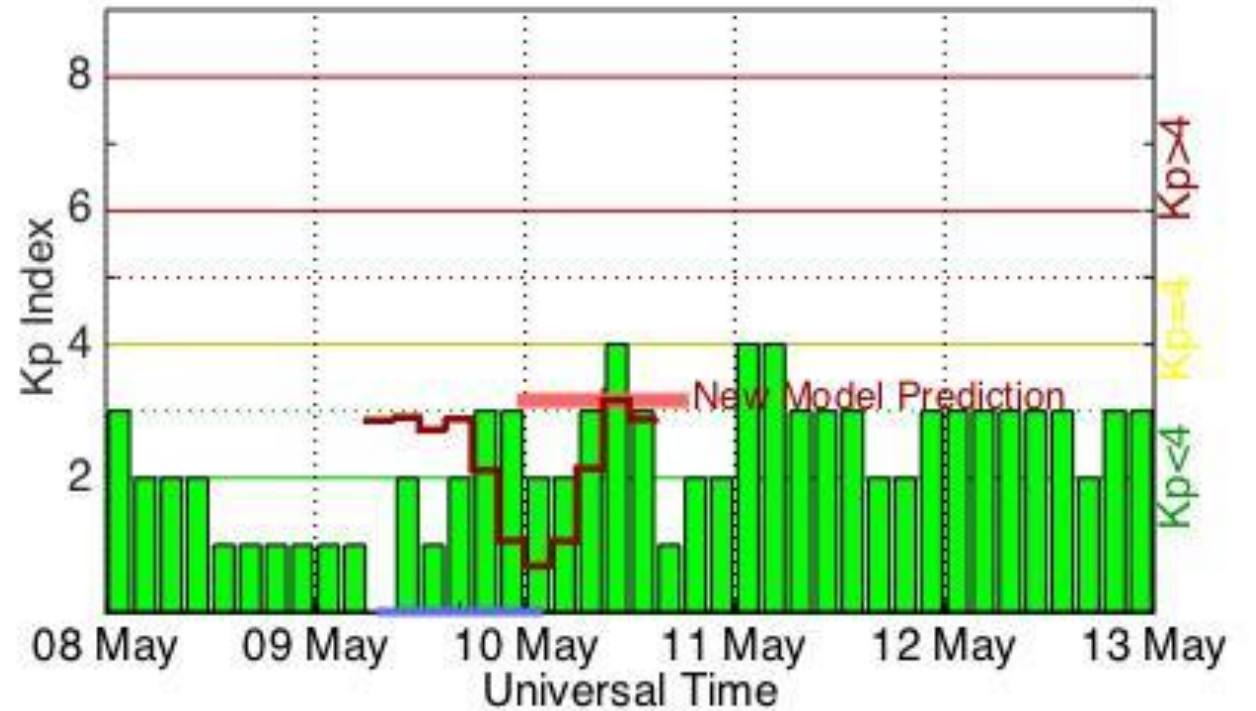
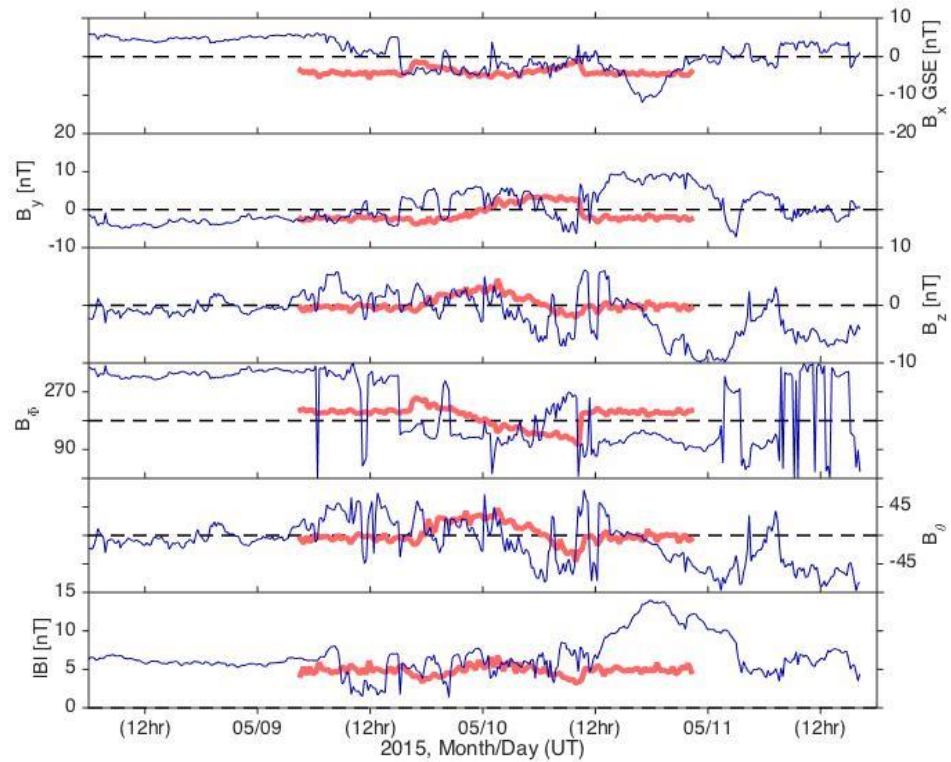
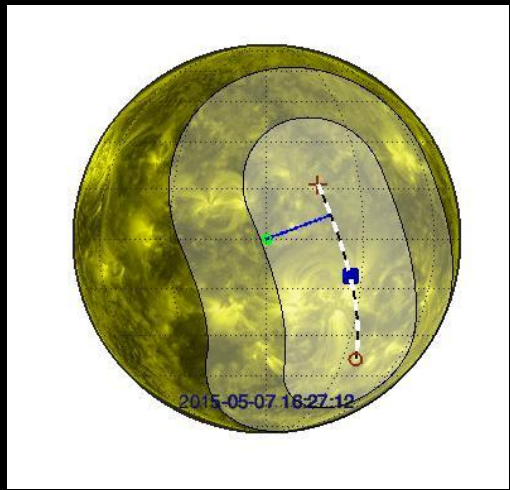
Bz Prediction



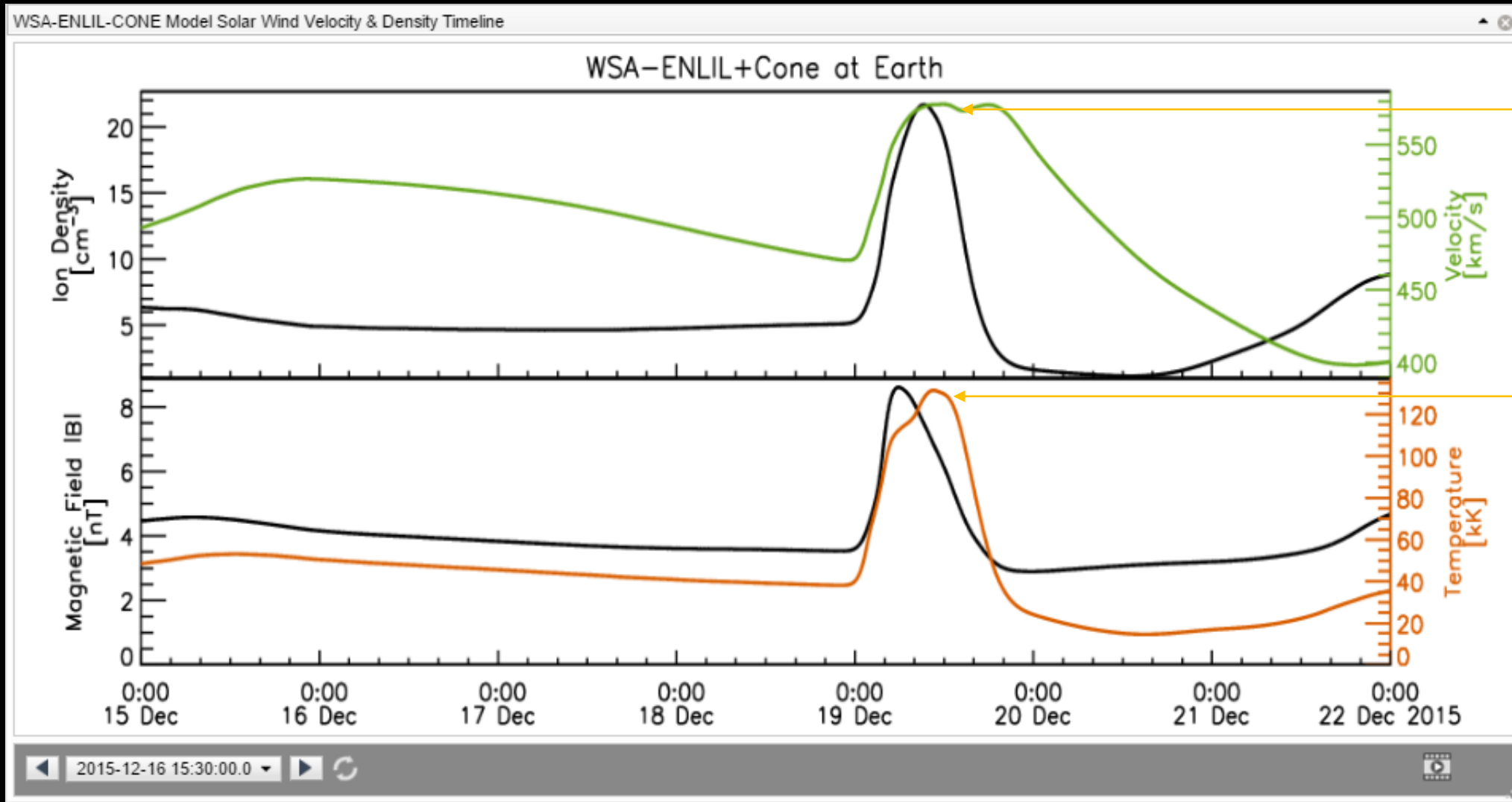
Inputs Part II



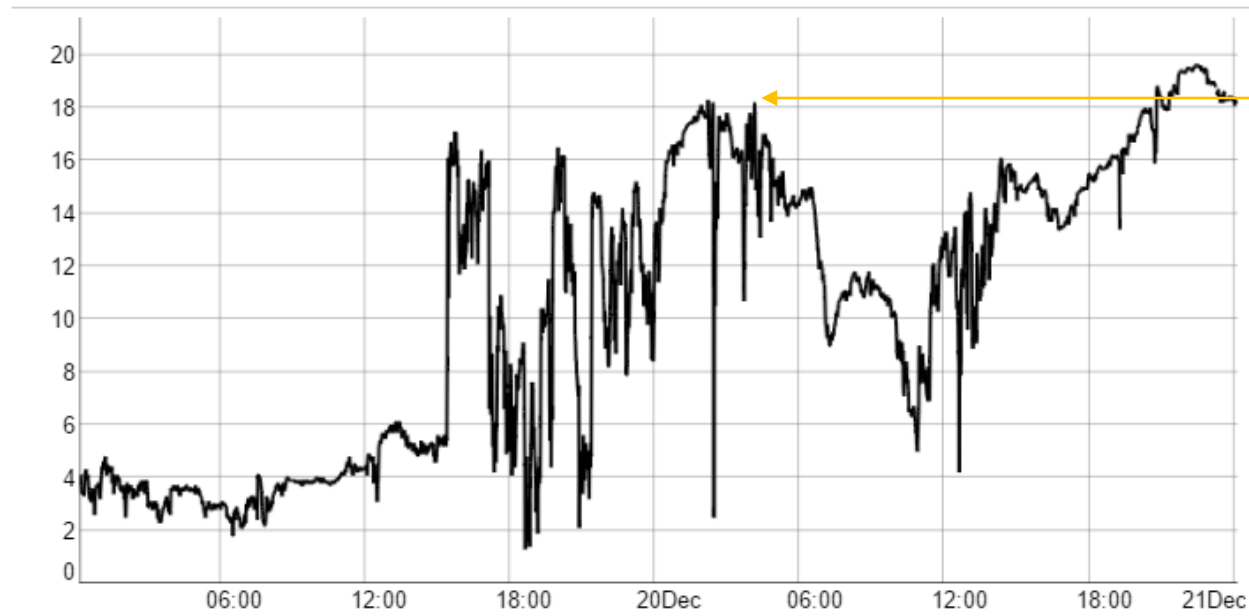
Outputs



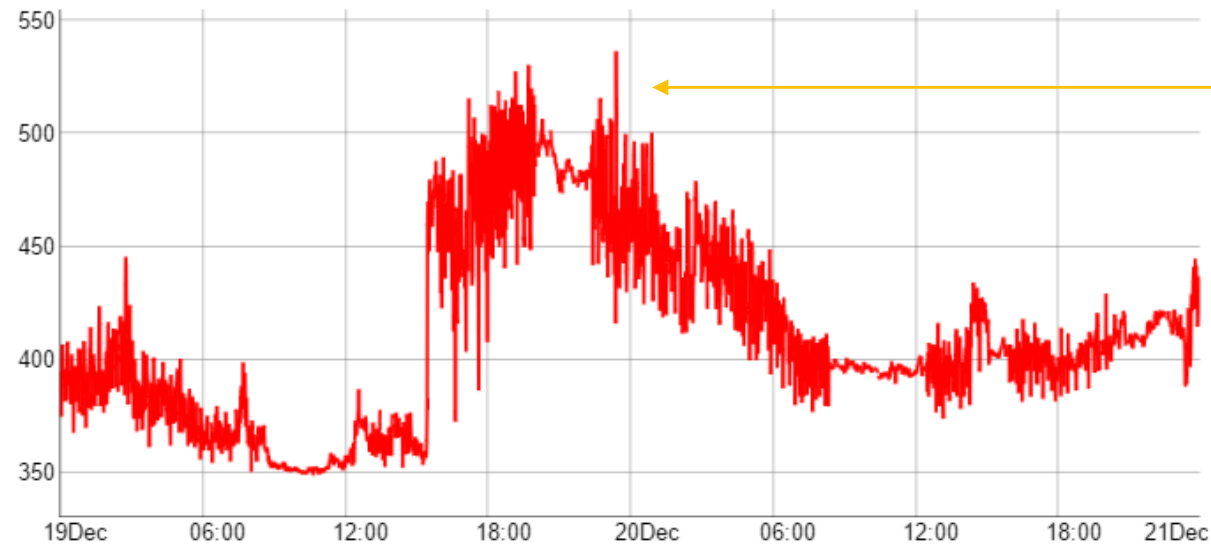
Real-Time Limitations Part I



Real-Time Limitations Part II



18.1 nT

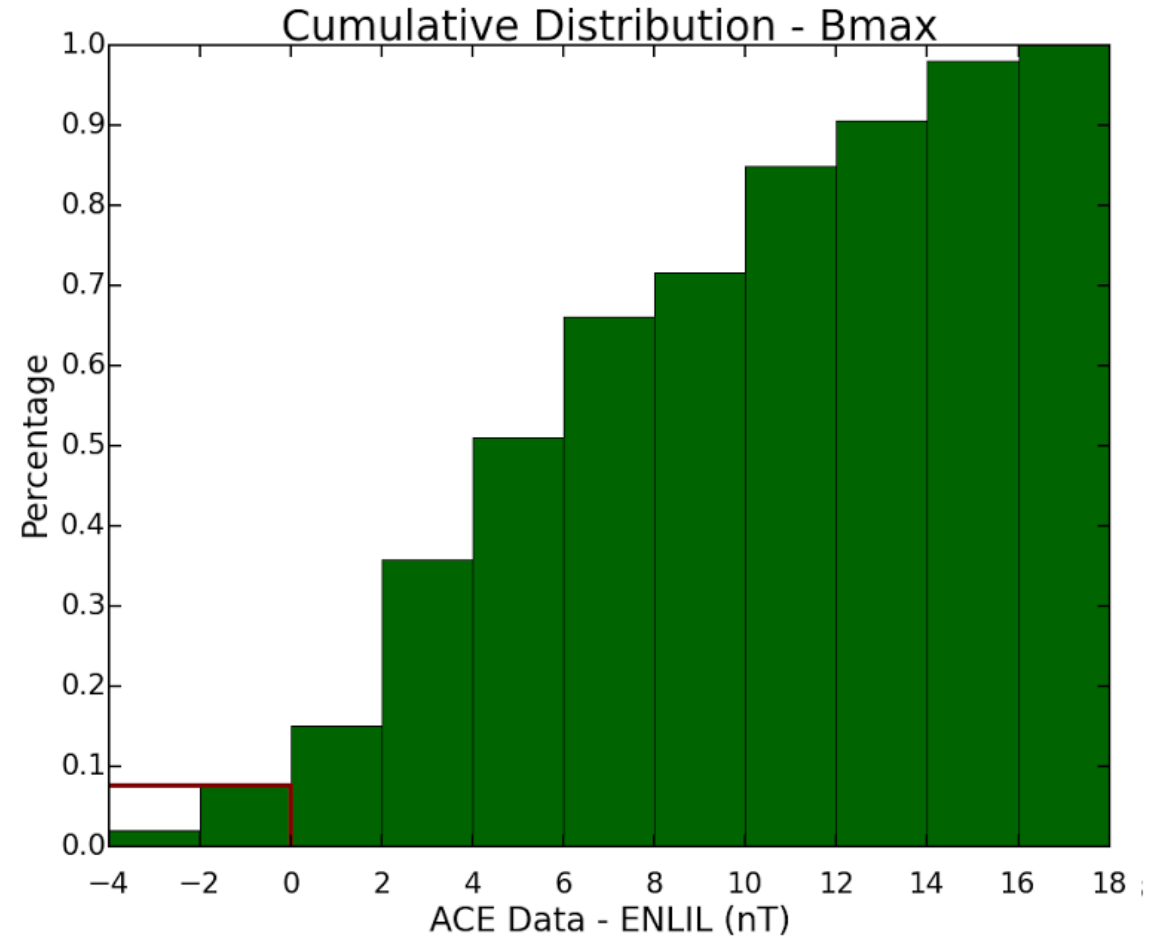
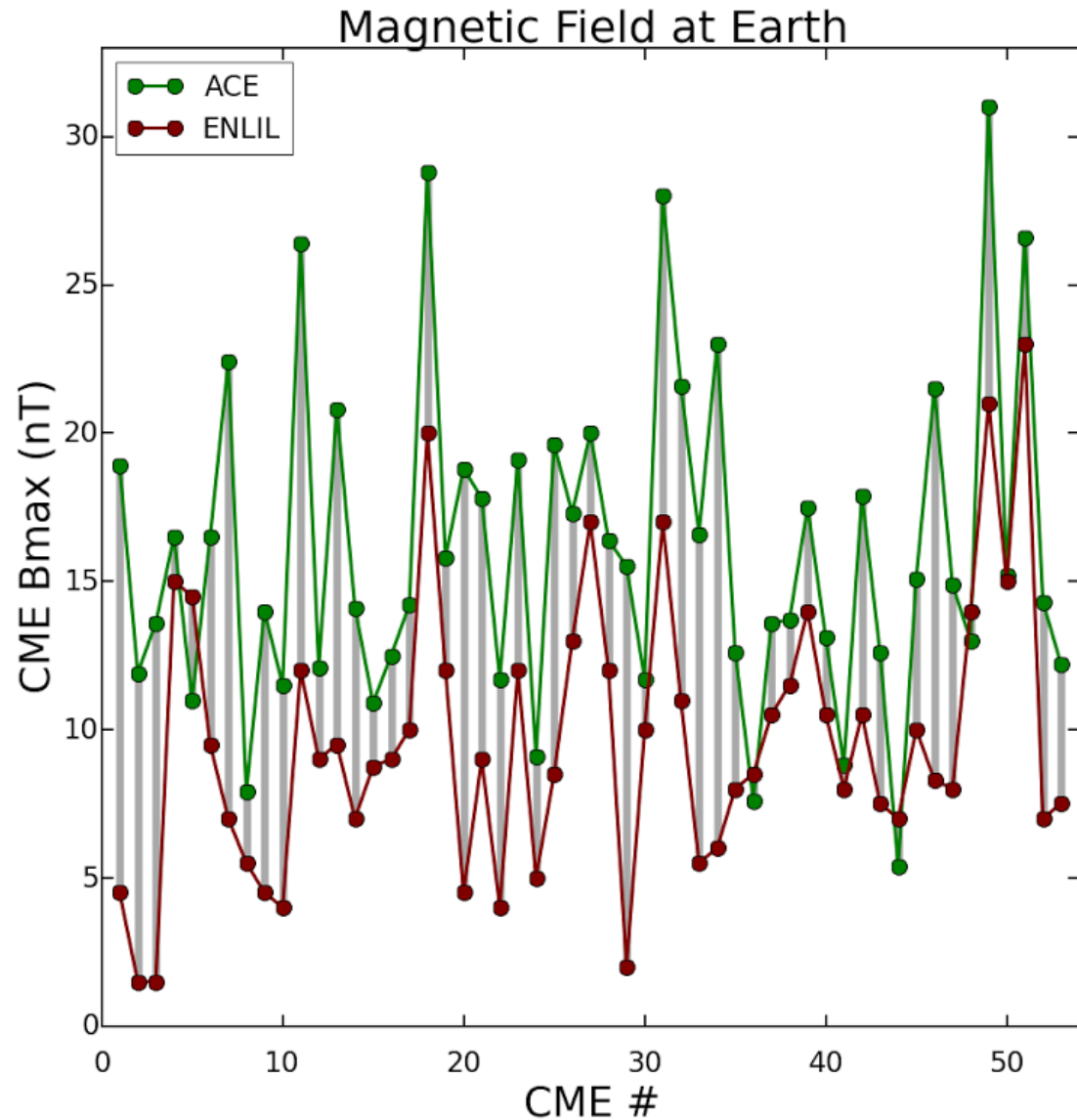


525 km/s

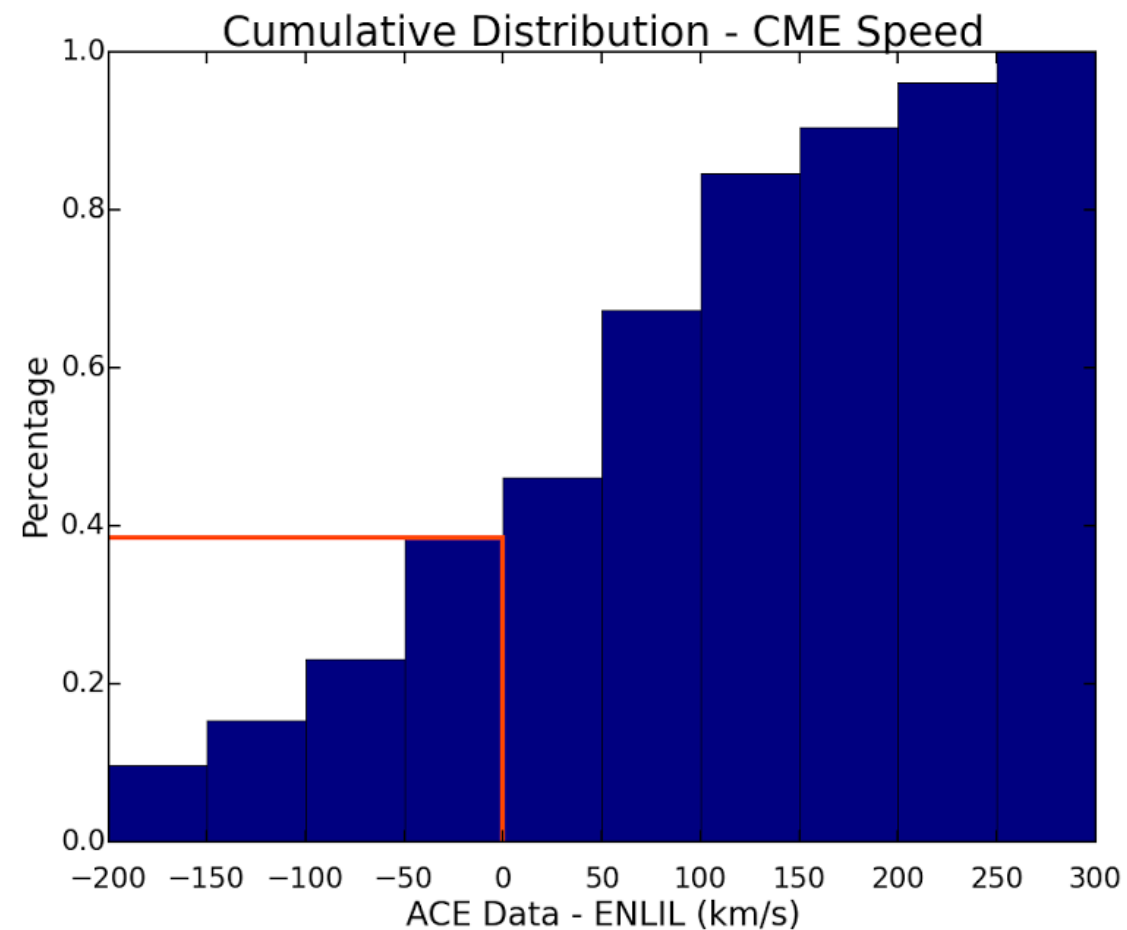
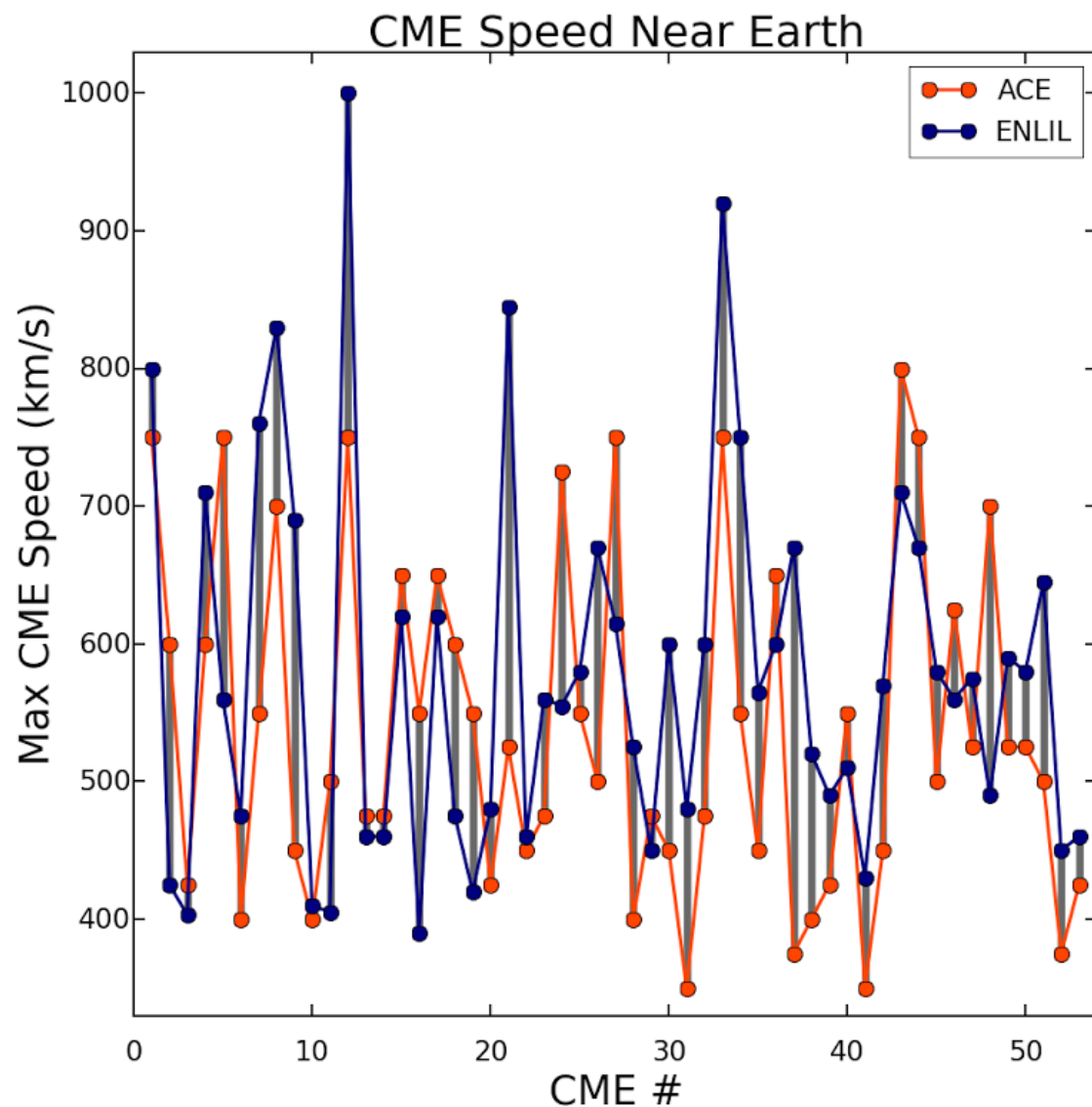
The background features a stylized illustration. On the left is a large, bright orange sun with a textured, slightly irregular surface. On the right is a large, detailed eye with a yellow iris and a black pupil, looking towards the sun. A beam of light, composed of several parallel lines, extends from the sun towards the eye. The overall color palette is dominated by orange, yellow, and black.

Chapter 3: Data Analysis

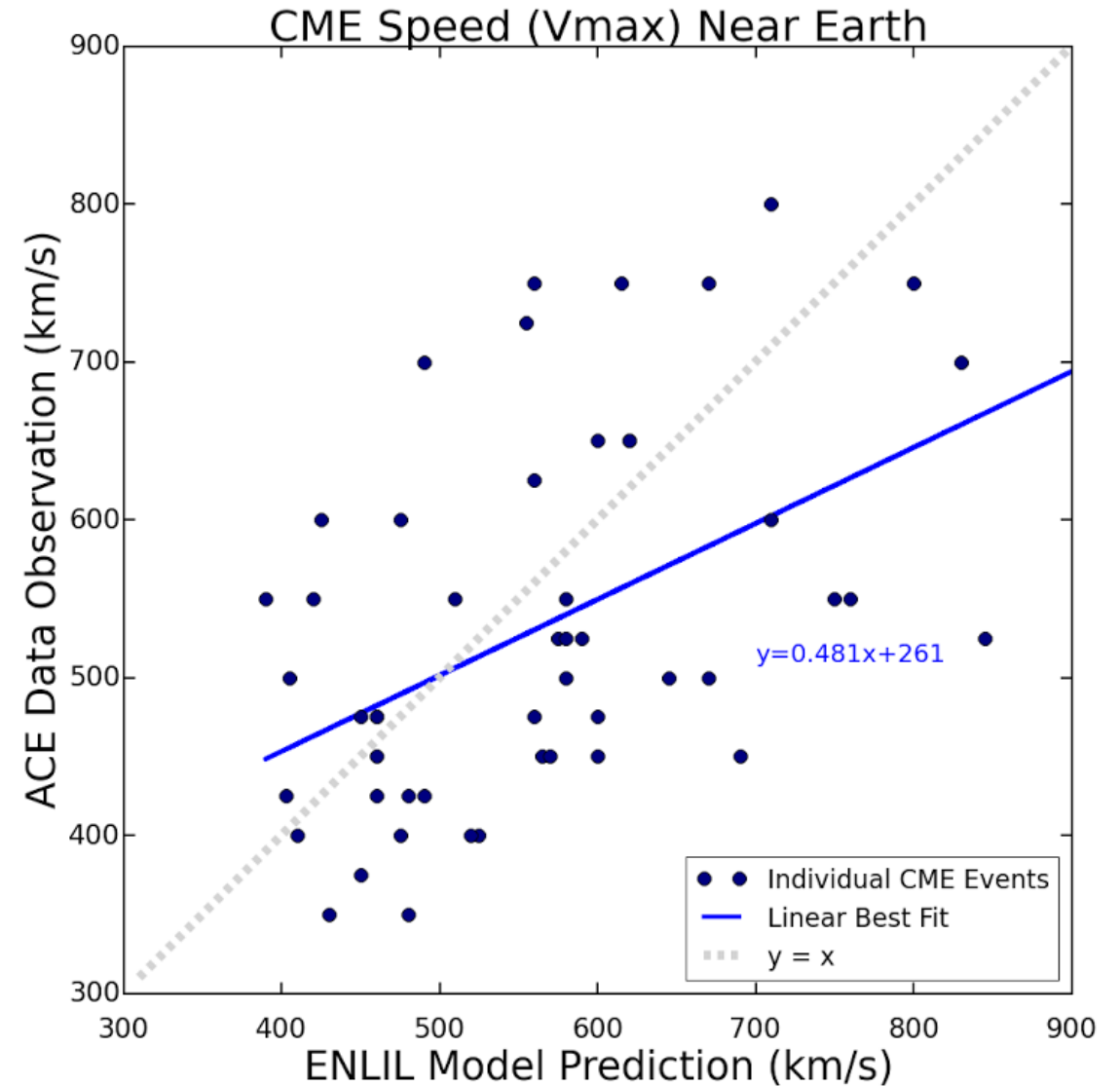
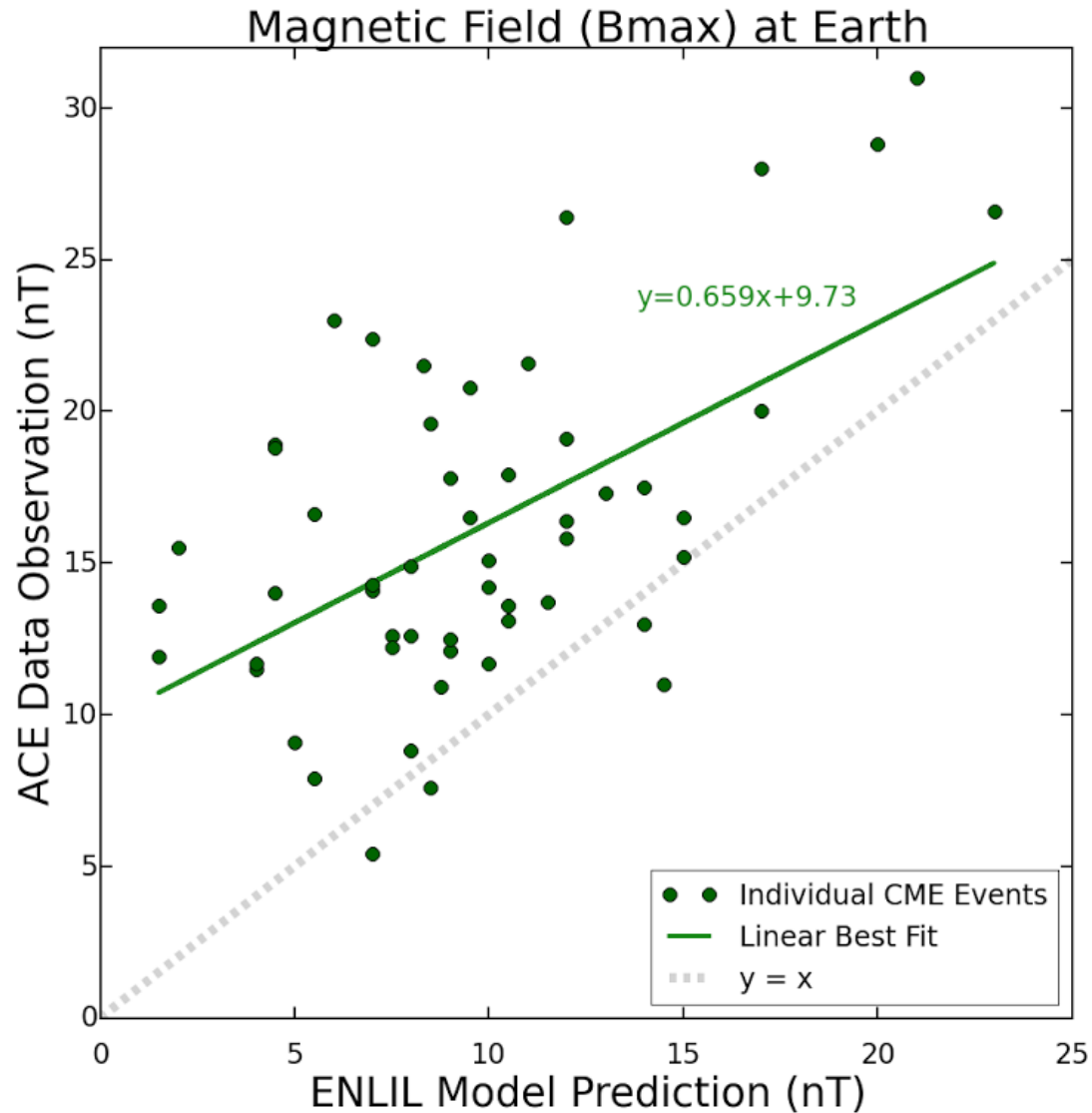
Analyzing ENLIL B-field Predictions



Analyzing ENLIL Velocity Predictions



Finding the “Rules of Thumb”





Chapter 4: Results and Discussion

Skill Score Overview

	Event Observed	
Event Forecast	Yes	No
Yes	A. Hit	B. False Positive
No	C. Miss	D. Correct Null

Skill Score Metric	Minimum	Maximum	Perfect Score
Proportion Correct	0	1	1
Hit Rate	0	1	1
False Alarm Rate	0	1	0
Frequency Bias	0	∞	1
Threat Score	0	1	1
True Skill Statistic (TSS)	-1	1	1

Proportion Correct = $(A + D) / n$

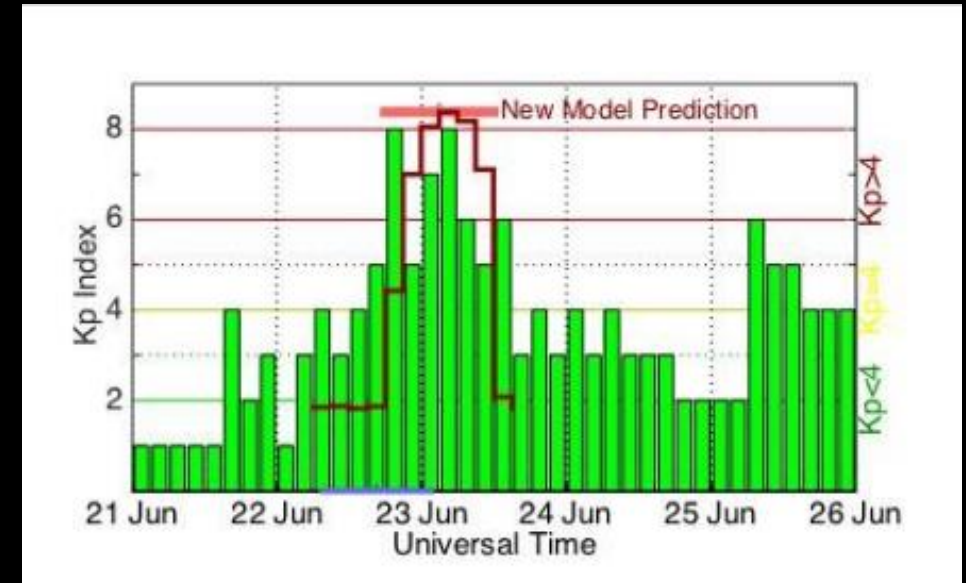
Hit Rate = $A / (A + C)$

False Alarm Ratio = $B / (A + B)$

Frequency Bias = $(A + B) / (A + C)$

Threat Score = $A / (A + B + C)$

TSS = $(AD - BC) / [(A + C)(B + D)]$



Results

Bz4Cast Performance for ENLIL and Modified Inputs

Bz4Cast Inputs	Hits	Misses	False Positives	Correct Nulls
ENLIL	28	37	23	187
Modified	28	37	39	171

Bz4Cast Skill Scores for ENLIL and Modified Inputs

Bz4Cast Inputs	Proportion Correct	Hit Rate	False Alarm Ratio	Frequency Bias	Threat Score	True Skill Statistic
ENLIL	0.78	0.43	0.45	0.78	0.32	0.32
Modified	0.72	0.43	0.58	1.03	0.27	0.25

Discussion

- Only frequency bias showed any improvement
- Four of the metrics were negatively impacted by the input modification
- Noticeable increase in the amount of false positives
- While magnetic field and velocity are relevant, they appear to be more of a second order effect
- Further avenues need to be explored before Bz4Cast can live debut as a real-time forecasting tool



The background of the slide is a deep-field astronomical image, likely from the Hubble Space Telescope, showing a vast field of galaxies. The galaxies are of various shapes and sizes, ranging from small, distant points of light to larger, more complex structures. The colors of the galaxies vary, with some appearing blue, others red, and many appearing white or yellow. The overall scene is a dense, dark space filled with distant celestial objects.

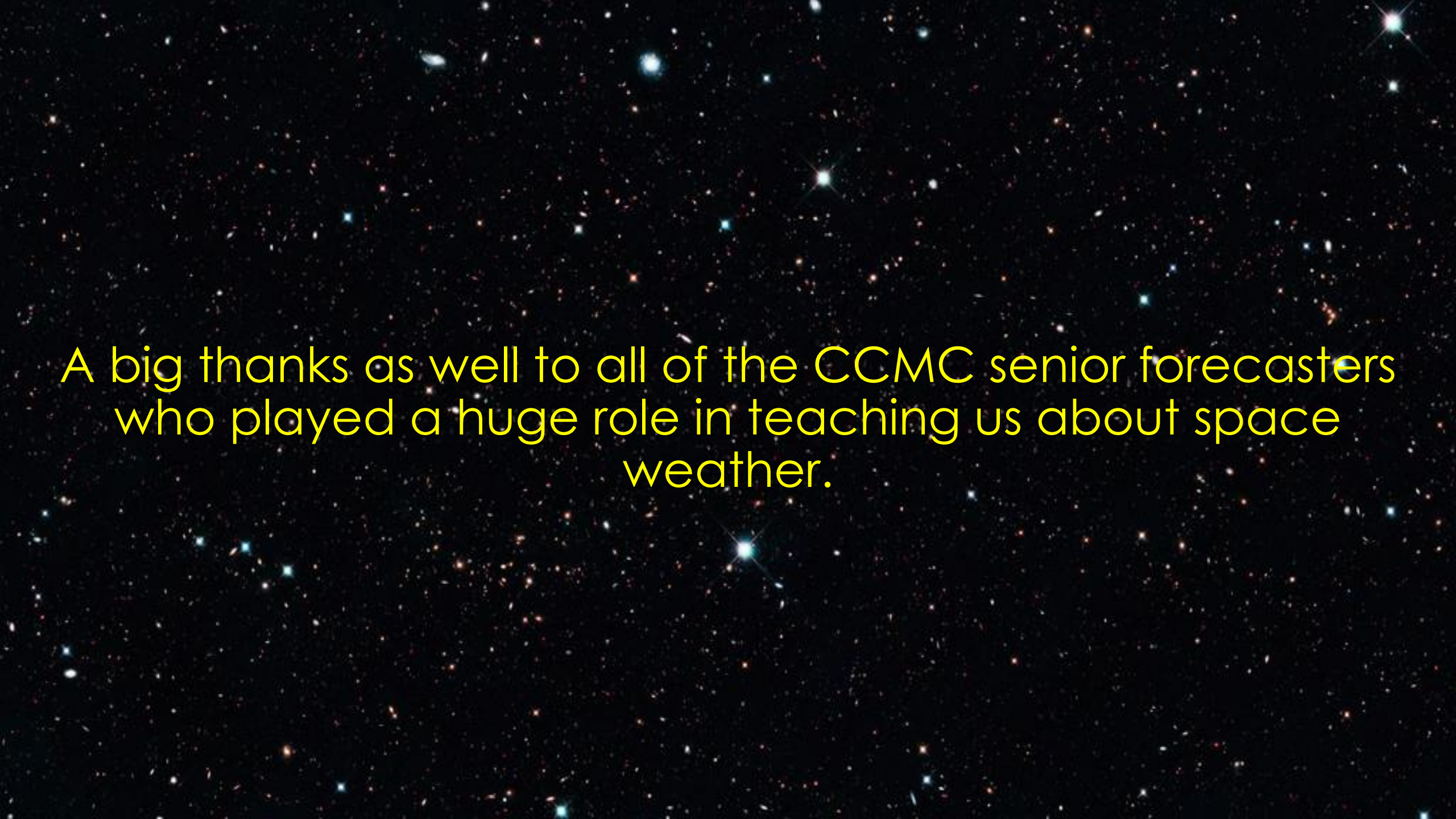
Acknowledgements

The background of the slide is a high-resolution astronomical image, likely from the Hubble Space Telescope, showing a vast field of galaxies. The galaxies are of various shapes and sizes, some appearing as bright, irregular blobs, others as more structured spirals or ellipses. They are scattered across the frame, with some being more prominent than others. The colors of the galaxies range from deep reds and oranges to bright blues and whites, indicating different temperatures and compositions. The overall effect is a sense of immense scale and cosmic diversity.

This project would not have been possible without the guidance and assistance of Neel Savani, Leila Mays, Yihua Zheng, Barbara Thompson, and Antti Pulkkinen.

The background of the slide is a high-resolution astronomical image, likely from the Sloan Digital Sky Survey. It shows a dense field of galaxies and stars. The galaxies are mostly small, distant, and appear as faint, irregular shapes in various colors (blue, red, white). The stars are larger, brighter, and have distinct diffraction patterns (spikes) around them. The overall scene is a deep space view, providing a cosmic context for the text.

We would also like to thank Teresa Nieves, Silvina Guidoni,
Lizz Bowlen, and the rest of the SESI team.

A deep space image showing a vast field of stars and galaxies against a black background. The stars are of various colors, including white, blue, and red, and are scattered across the frame. Some stars are bright and prominent, while others are faint and distant. The overall scene is a dense field of celestial objects.

A big thanks as well to all of the CCMC senior forecasters
who played a huge role in teaching us about space
weather.